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Training with mild anxiety may prevent choking under higher levels of anxiety

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A B S T R A C T

Objective: The aim of the study was to examine whether training with mild levels of anxiety helps in maintaining performance under higher levels of anxiety.

Methods: Novices practiced dart throwing while they were hanging low on a climbing wall either with or without mild anxiety. After training, participants were tested under low, mild, and high anxiety (in the latter case high on the climbing wall).

Results: Despite systematic increases in anxiety, heart rate, and perceived effort from low to mild to high anxiety the group that had trained with anxiety performed equally well on all three tests, while performance of the control group deteriorated with high anxiety.

Conclusion: It is concluded that practicing perceptual-motor tasks under mild levels of anxiety can also prevent choking when performing with higher levels of anxiety.

Preparing for the Olympic Games or another final of an important tournament is always a challenge, not just physically but also psychologically because it is difficult to prepare for the pressures that athletes may encounter in performing at that level. An often heard comment is that it is not possible to train for these pressures as they are too high and too context-specific. However, to our knowledge it has never been properly investigated whether this is indeed the case. Therefore, in the current study a first attempt was made to examine whether training with mild anxiety, a level that can be simulated in practice, may help in preventing choking under higher levels of anxiety. We tested anxiety because in the end it is not the pressure itself that causes choking but the state anxiety it may evoke. State anxiety can be defined as an aversive emotional and motivational state as a result of threat, which is "related to the subjective evaluation of a situation, and concerns jeopardy to one's self-esteem during performance or social situations, physical danger, or insecurity and uncertainty" (Schwenkmezger & Steffgen, 1989, pp. 78–79).

In search for an explanation for choking under pressure-induced anxiety,[1] it has been proposed that anxiety is accompanied by changes in attention. On the one hand, these changes may involve changes to internal processes characterized by elevated levels of self-consciousness often in the form of more worries and self-focused attention (Adegbesan, 2007; Beilock & Gray, 2007; Sarason, 1988; Wegner & Giuliano, 1980; Wilson & Smith, 2007). On the other hand, the changes may concern visual attention, with less efficient gaze behaviour manifesting itself in higher search rates and shorter quiet eye durations (Behan & Wilson, 2008; Janelle, 2002; Janelle, Singer, & Williams, 1999; Murray & Janelle, 2003; Nieuwenhuys, Pijpers, Oudejans, & Bakker, 2008; Vickers & Williams, 2007; Williams, Vickers, & Rodrigues, 2002). These attentional changes may distract from primary task execution, leading to hampered performance.

An emerging theory that provides a comprehensive account of the mechanisms behind the effects of anxiety on performance, including the proposed changes in attention, is attentional control theory (Eysenck, Derakshan, Santos, & Calvo, 2007), which has recently been developed on the basis of processing efficiency theory (Eysenck & Calvo, 1992). Although attentional control theory and processing efficiency theory are claimed to have most relevance to cognitive performance, several studies have provided empirical support for the processing efficiency theory with respect to perceptual-motor tasks (Mullen & Hardy, 2000; Mullen, Hardy, & Tattersall, 2005; Murray & Janelle, 2003; Nieuwenhuys et al., 2008; Smith, Bellamy, Collins, & Newell, 2001; Williams et al., 2002; Wilson, Smith, Chattington, Ford, & Marple-Horvat, 2006). According to processing efficiency theory there are two kinds of processes in response to anxiety. First, anxiety may lead to worry about task performance, which will "pre-empt some of the processing and storage resources of the working memory

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[1] Note that choking under pressure is a complex phenomenon that relates to several factors, such as dispositional self-consciousness and trait anxiety (Baumeister, 1984; Heaton & Sigall, 1991; Wang et al., 2004), task characteristics (cognitive or perceptual-motor tasks: Beilock & Carr, 2001, 2005; Markman, Maddox, & Worthy, 2006; precision or non-precision tasks: Baumeister, Hutton, & Cairns, 1990), and the presence and type of audience (Butler & Baumeister, 1998; Wallace, Baumeister, & Vohs, 2005). It is beyond the scope of the current study to cover all these topics. Instead we will focus on the underlying mechanisms as they relate to the possible positive effects of training with anxiety to prevent choking in perceptual-motor tasks.

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system'' (Eysenck & Calvo, p. 415), possibly leading to hampered performance. Second, although worry may tax working memory processing and capacity, the adverse effects of anxiety may be compensated for by a second stream of processes involving increased on-task effort and activities to improve performance (Eysenck & Calvo). In support of this proposal, studies investigating perceptual-motor performance have found that increases in state anxiety are often accompanied by a concomitant increase in perceived effort (e.g., Oudejans & Pijpers, 2009; Williams et al., 2002; Wilson et al., 2006; Wilson, Smith, & Holmes, 2007).

Particularly, the additional self-regulatory processes that are proposed to reduce the negative effects of anxiety on performance may offer a solution for choking, as these processes may actually improve and become more effective through training with anxiety. Following exposure to higher levels of anxiety during task execution, experts and novices alike may learn to perform better under pressure by getting better at the performance-enhancing self-regulatory processes leading to more effective attempts to counter the negative effects of anxiety (cf. Lewis & Linder, 1997; Oudejans & Pijpers, 2009). Recently, it was shown that practicing perceptual-motor tasks under circumstances that lead to mild levels of self-consciousness or anxiety, such as competition or camera recording, may indeed help in maintaining later performance under similar circumstances with mild anxiety. Beilock and Carr (2001) and Lewis and Linder (1997), for instance, demonstrated that when beginners learn a golf putting task under conditions with increased self-consciousness they eventually perform better with similarly increased self-consciousness (cf. Baumeister, 1984). In addition, it was shown that following practice with mild-anxiety expert performance of basketball players, dart players, and police officers also no longer deteriorated with similar levels of anxiety (Oudejans, 2008; Oudejans & Pijpers, 2009). Apparently training with mild anxiety is effective in preventing the negative effects of similar levels of mild anxiety on performance.

A question that remains is whether training with certain levels of anxiety also transfers to performance contexts with even higher levels of anxiety, for instance, levels of anxiety with which performers are likely to be confronted in their actual performance environment (e.g., during the Olympic Games, or when taking a decisive penalty kick at the World Championships football). In the studies described above, performers were both trained and tested in conditions with similar levels of anxiety, that is, anxiety was manipulated in the same way during practice sessions and performance tests. The aim of the current study was to examine whether practicing with *mild* levels of anxiety also prevents choking when eventually performing under *higher* levels of anxiety.

As choking may be defined as a failure to reach the level of performance that can be expected on the basis of one's abilities whether it concerns novices or experts (Baumeister, 1984), we decided to examine novices learning a relatively easy dart throwing task. To induce mild levels of anxiety we chose several ego-stressor methods (similar to the studies by Beilock & Carr, 2001, Lewis & Linder, 1997, and Oudejans & Pijpers, 2009). To induce higher levels of anxiety we chose a performance environment of which there is much evidence that it consistently induces such higher levels of anxiety, namely an indoor climbing wall (e.g., Pijpers, Oudejans, & Bakker, 2005; Pijpers, Oudejans, Holsheimer, & Bakker, 2003). Participants first practiced dart throwing while positioned low on the wall either with (experimental group) or without (control group) experimentally induced mild levels of anxiety. In the end, participants were tested under low, mild as well as higher levels of anxiety, with higher levels of anxiety being induced by having participants throw darts while hanging high instead of low on the climbing wall. To check the effects of the manipulations, levels of anxiety and perceived effort were determined during the tests and training sessions. According to the attentional control theory, perceived effort may provide an indication of the level of self-consciousness (Eysenck et al., 2007). Increases in perceived effort would then be an indication of the allocation of additional resources in an attempt to counter the negative effects of anxiety, as was also found in earlier studies (Mullen & Hardy, 2000; Mullen et al., 2005; Murray & Janelle, 2003; Nieuwenhuys et al., 2008; Smith et al., 2001; Williams et al., 2002; Wilson et al., 2006).

We expected that during the training sessions subjectively experienced anxiety of the experimental group would be higher than during the pretest. Furthermore, we expected that for both groups anxiety would increase from the low to the mild to the high anxiety posttest. Following attentional control theory (Eysenck et al., 2007), we also expected that for both groups these increases in anxiety would be accompanied by increases in self-consciousness as indirectly assessed by measuring perceived effort. Furthermore, we expected that due to training with anxiety attempts to counter its negative effects would have become more effective for the experimental group leading to a maintenance of performance over the anxiety posttests. In contrast, we expected that performance of the control group would decrease either during the mild or the high anxiety posttest or during both, despite increases in perceived effort, and hence, allocation of additional resources. Due to a lack of training with anxiety we expected that these additional self-regulatory processes would not be effective for this group (we will address this issue more extensively in the Discussion section).

Method

Participants

Twenty four Dutch persons (16 men and 8 women), mainly college students, without experience in dart throwing volunteered to participate. All were self-reported right-handed and their average age was 22.5 ± 3.2 years. Participants were randomly assigned to one of two groups, an experimental group (EG; 7 men, 5 women) and a control group (CG; 9 men, 3 women). The experimental group practiced dart throwing under experimentally induced mild levels of anxiety, while the control group practiced without additional anxiety. The Dutch version of the A-Trait scale of the State-Trait Anxiety Inventory (STAI, Van der Ploeg, Defares, & Spielberger, 1980) was used as a standard check to measure trait anxiety (both in the experimental and the control group one measurement was missing). The mean trait anxiety scores of neither the women ($M = 37.7$, SD = 8.2) nor the men ($M = 34.1$, SD = 7.2) differed significantly from the mean scores for Dutch college students ($M = 37.7$ and $M = 36.1$ for women and men, respectively, Van der Ploeg et al.) on a t test between a sample and a population mean, $t(6) = .01$, $p = .99$, and $t(14) = 1.1$, $p = .29$. These results indicate that participants had no extraordinary tendency to respond to situations perceived as threatening with an elevation in state anxiety. Mean trait anxiety scores of the experimental group, $M = 37.8$, SD = 9.1, and control group, $M = 32.6$, SD = 4.8, did not differ significantly on a t test, $t(20) = 1.68$, $p = .11$.[2]

[2] Note that STAI scores do not provide a baseline measure for anxiety. They provide a rough indication of the tendency of participants to respond to certain situations with increased anxiety. We used STAI scores as a check to make sure that possible findings concerning effects of anxiety would not simply be the result of participants (either in the experimental or control group) having an extraordinary tendency to respond with anxiety. Given that the STAI scores refer to a general tendency of participants, these scores do not necessarily mean that participants also actually would respond with corresponding levels of anxiety in our experimental conditions, making them unsuitable to be used as a covariant in subsequent statistical analyses.

Design

Prior to the experiment the protocol was approved by the institutional ethics committee. The study consisted of a pretest, two training sessions and three posttests. The pretest and first training session were executed on the same day. The second training session and the posttests were executed 2–4 days later (on the same day), depending on the availability of the participants. As participants were not expert dart players a high anxiety pretest was considered of little value as stable performance levels were not yet expected. The pretest was merely to determine the pre-training performance, anxiety, and effort levels. During the pretest participants threw 24 darts. During the first training session participants threw 240 darts (cf. Beilock & Carr, 2001). The second training session was somewhat shorter than the first session (as it was followed by three posttests) and consisted of 192 throws. Each training session lasted between 25 and 35 min. The three posttests, low anxiety, mild anxiety, and high anxiety, each consisted of 24 throws. The order of the posttests was varied such that in each group (EG, $n = 12$; CG, $n = 12$) each of the six possible order combinations was used twice.

Material and experimental set-up

For the purpose of the high anxiety manipulation participants threw all their darts while they were positioned on a vertical climbing wall (width: 3.5 m, height: 7.0 m; see Fig. 1), which was set-up in a large laboratory at a distance of 1.45 m from the back wall of the room. On the climbing wall, at two different heights four holds were bolted, two footholds and two handholds (see Fig. 1). The mean height of the footholds in the low condition was .14 m above the ground. The height of the two handholds was 1.84 m in this condition. The height of foot- and handholds in the high condition (only used during the high pressure posttest, see Procedure) was 3.96 m and 5.66 m, respectively. In order to take position on the climbing wall in the high condition a large stepladder was used. The stepladder had a small platform that allowed participants to rest after having climbed it and to start the high condition in the same physical (i.e., non-fatigued) condition as the tests low on the wall. Participants threw their darts at the dart board (Dartset) that was attached to the back wall of the room .35 m next to the right side of the climbing wall and 1.45 m further in depth (see Fig. 1). The resulting throwing distance (about 1.45 m) was shorter than the normal match distance of dart throwing of 2.37 m. This shorter distance also made the dart task much easier than ordinary dart throwing, hereby ensuring that within the training sessions the participants already reached a reasonable level of performance. The height of the bulls-eye of the dart board was 1.64 m (regulation height) above the footholds in both height conditions. The diameter of the dart board was .46 m. The face of the board showed ten circles varying in colour between black and white, each circle yielding a certain number of points per dart starting with 10 when bulls-eye was hit to 0 points when the dart board was not hit at all.

The anxiety scores were obtained using a visual-analogue anxiety scale, called the anxiety thermometer, which was validated for the Dutch population by Houtman and Bakker (1989) and successfully used in earlier experiments (Pijpers et al., 2003, 2005). The anxiety thermometer is a 10-cm continuous scale on which participants rated their anxiety feelings, ranging from 0 (*not anxious at all*, the left end) to 10 (*extremely anxious*, the right end). The anxiety thermometer provides a quick and reliable way to measure state anxiety (cf. Pijpers et al., 2005), in contrast to the often used Competitive State Anxiety Inventory-2 (CSAI-2, Martens, Vealey, & Burton, 1990). Although, the anxiety thermometer does not take into account the distinction between cognitive and somatic anxiety as measured with the CSAI-2, scores appear to correlate equally with cognitive and somatic anxiety scores on the (Dutch translation of the) CSAI-2, on average $r = .59$ and $r = .62$, respectively (Bakker, Vanden Auweele, & Van Mele, 2003).[3] Generally, validity and test-retest reliability of the anxiety thermometer are fair, with correlation coefficients ranging between .60 and .87 for several comparisons (Bakker et al.; Houtman & Bakker), including comparisons between anxiety scores taken before or after an event. This provides support for the validity of a measurement procedure in which feelings of anxiety are obtained after the event which was done in the current study. After each test or training session individuals placed a small vertical line on the scale to indicate how they had felt during that test or session. The distance between the left end and the vertical line (in cm) was used as a measure of anxiety.

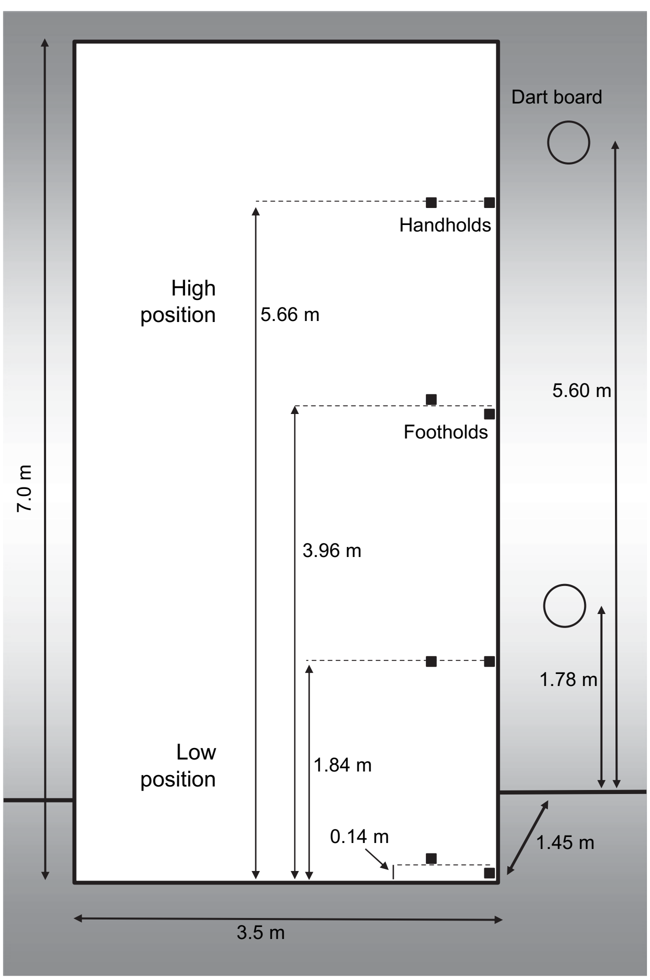

Fig. 1. Front view of the climbing wall and the dart boards (circles) positioned high and low next to the wall. The positions of the holds are indicated by black squares.

[3] Note that there are several alternatives for the anxiety thermometer for English or American populations such as the Mental Readiness Form-3 (MRF-3; Krane, 1994) and the Immediate Anxiety Measure Scale (IAMS, Thomas, Hanton, & Jones, 2002). Correlations of the MRF-3 with the CSAI-2 are comparable to correlations between the anxiety thermometer and CSAI-2. Overall, the recently developed IAMS seems to have a somewhat higher validity and reliability than the other measures. However, for brief measurements close to the event correlations with CSAI-2 also seem to be comparable to those of MRF-3 and the anxiety thermometer with CSAI-2. Moreover, the anxiety thermometer is the only instrument extensively tested for the Dutch population, from which the participants of the current study were taken.

We also assessed heart rate using a Polar Electro heart rate monitor during the pretest and posttests. Although heart rate (beats per minute, bpm) is an indicator of physiological arousal (not anxiety), it is generally assumed that in situations with comparable levels of physical exertion heart rate can provide some indication of anxiety (Åstrand, Rodahl, Dahl, & Strømme, 2003). As during the tests participants executed the same brief darts task without additional (climbing) movements, we felt it safe to assume that in the tests elevations in heart rate would provide additional confirmation of the success of our manipulation (cf. Oudejans, 2008; Oudejans & Pijpers, 2009). Because the training sessions with 240 and 192 darts, respectively, lasted longer than the tests, different levels of physical exertion were expected, disqualifying heart rate as an indicator of anxiety during the training sessions.

The perceived effort was measured using the effort scale (Hardy & Jackson, 1996; Mullen & Hardy, 2000). Just as the anxiety thermometer this is a continuous scale from 0 (extreme left, *no effort at all*) to 10 cm (extreme right, *most effort ever*) on which participants indicated their invested effort during a test by putting a small vertical line on the 10 cm horizontal line. The distance between the left end and the vertical line (in cm) was used as a measure of the effort. The effort scale is considered a valid and reliable measure of invested effort (Hardy & Jackson; Mullen & Hardy).

For safety reasons participants had to be secured high on the climbing wall. Therefore, and to keep conditions as similar as possible, participants were secured during all the tests (but not the training sessions) using a climbing harness (Singing Rock, Zenith, Type C) and the so-called 'top-roping' technique (Skinner & McMullen, 1993).

Parts of the experiment were recorded with a digital video camcorder (JVC, type GR-D239E). The camcorder provided one of the manipulations used to increase the pressure during the training sessions of the experimental group and during the mild pressure posttest. It was positioned on a tripod behind the participant. Camera recording has been used successfully to increase pressure in several earlier studies (Carver, Antoni, & Scheier, 1985; Heaton & Sigall, 1991). On occasion the camcorder was taken off the tripod to film the participants from closer and more to the front. This was done to remind the participants of the recordings being made to maintain the mild pressure manipulation.

Procedure

Each participant was trained and tested individually. After a brief explanation of the experiment the participant gave his or her written informed consent and completed the STAI. Then the heart rate monitor was placed and the participant put on the climbing harness and was secured. The pretest was subsequently executed without any attempts to manipulate pressure or anxiety. The participant took position low on the climbing wall using the mounted holds (Fig. 1). A stable position was obtained using the left handhold and the two footholds, leaving the right arm free for dart throwing. The participant then threw the first three darts attempting to score as many points as possible. This was done eight times yielding the pretest of 24 throws. After each set of 3 darts an experimenter recorded the score on paper, took the darts from the board and returned them to the participant. Furthermore, after each three throws the participant could, whenever he or she felt the need, grasp the right handhold with the right hand, slightly change position and release the tension on the muscles to prevent fatigue. Immediately after the last dart participants came off the wall and completed an anxiety thermometer and an effort scale. They were instructed to indicate how anxious they had felt and how much effort they had exerted while throwing the 24 darts. The pretest lasted about 5 min.

The first training session started 10 min after the pretest. The participant took position low on the wall (Fig. 1) and threw 40 sets of 6 darts totalling 240 darts. After each set of 6 darts an experimenter recorded the scores and returned the darts to the participant. Whenever the participant felt the need s/he could (slightly) reposition between the sets or even come of the wall to take a short break to prevent fatigue. Immediately after 240 darts the participant came off the wall and completed an anxiety thermometer and effort scale with the instruction to indicate how they had felt during the training session. The second training session took place 2–4 days later and consisted of 32 sets of 6 darts totalling 192 darts. Each training session lasted 25–35 min.

Training sessions of the experimental group were similar to those of the control group apart from several manipulations to induce anxiety. First, training sessions were recorded with the digital video camera and participants were told that recordings would be used in a popular scientific television program and that experts would analyze the images to shed light on the learning process. Second, participants were told that they were coupled with another participant and that the combined scores (of both training sessions) of the best couple would lead to a reward of 10 Euros each. To further increase the pressure, participants were told that their 'partner' had already done very well, so it all depended on them now. Eventually, the two best darters during the training sessions received 10 Euros each. Both the social pressure and a rewarding system (including the element of competition) may lead to increased anxiety. Third, participants were told that each sixth dart would earn double points, hereby increasing the importance of these specific throws and the pressure to perform well on these throws. To further increase the element of competition participants were finally told that a list of participants and their scores would be circulated. Several of these manipulations have been applied successfully in earlier studies (e.g., Baumeister, 1984; Beilock & Carr, 2001; Lewis & Linder, 1997; Mullen & Hardy, 2000; Mullen et al., 2005).

Each participant executed three posttests (low anxiety, LA, mild anxiety, MA, and high anxiety, HA) after they were rested from the second training session. Each posttest consisted of eight series of three darts, totalling 24 darts per test. During all tests participants wore the heart rate monitor and the climbing harness so that they could be secured. The LA posttest was similar to the pretest. When the LA posttest was the first or second posttest participants were told that these 24 darts were just additional practice to prepare for the test(s) to keep the pressure as low as possible (having to execute a test may already increase the pressure to perform well). When the LA posttest was the last test participants were told that this test was just to complete the data set. During the MA posttest anxiety was increased using the same manipulations that were used during the training sessions of the experimental group. As participants from the experimental group were already familiar with these manipulations possibly reducing their effectiveness an additional manipulation was introduced: The best score with the sixth darts (double points) would earn 10 Euros. As a result participants could quickly earn 20 Euros with this test, 10 Euros for the best couple and 10 Euros for the best sixth-dart performance. The HA posttest was the same as the LA posttest except that it was executed high on the climbing wall hereby increasing anxiety (cf. Oudejans & Pijpers, 2009; Pijpers et al., 2003). During the HA posttest one of the experimenters stood on a heightened platform behind the climbing wall in order to return the darts to the participants. This experimenter also wore a climbing harness with which he was secured to an iron bar construction behind the climbing wall. Immediately after each test participants came off the wall and completed an anxiety thermometer and effort scale with the instruction to indicate how they had felt during the test. For each measurement and each individual, a separate anxiety thermometer and effort scale was used. After the final test participants took off the harness and heart rate monitor. Then participants were fully debriefed, questions were answered and participants were thanked for their participation.

Statistics

Because each of the three dependent variables, anxiety scores, heart rates, and effort scores, could provide some indication of the success of our manipulation and because each was expected to increase from LA, to MA, to HA they were analyzed using several mixed design multiple analyses of variance (MANOVAs) with Group (control, experimental) as between-participants factor and repeated measures involving different sessions or tests. The dart scores were analyzed using similar mixed design ANOVAs. Effect sizes were calculated using Cohen's f with .10 or less, about .25, and .40 or more, representing small, moderate, and large effects, respectively (Cohen, 1988).

Results

Mean anxiety scores, heart rates (bpm), effort scores and dart scores are presented in Table 1. As the main focus of the current study is the comparison of the dependent variables regarding the LA, MA, and HA tests, the results regarding these tests will be presented in detail. The results regarding the pretest and training sessions were to check whether there were no a priori differences between the two groups other than those related to the manipulation of anxiety during the training sessions. Therefore, these results will only be briefly described (details can be obtained from the authors upon request). It was found that the pressure manipulations led to higher anxiety scores for the experimental group during training Session 1 in comparison to the pretest and training Session 2 ($ps < .05$). For the control group no significant differences were found among the anxiety scores on the pretest and the training sessions (Table 1). Regarding perceived effort it appeared that for both groups the first training session of 240 throws was perceived as significantly more effortful than the pretest (24 throws) and the second training session (192 throws; $ps < .05$). Just as anxiety and effort scores, mean heart rates did not differ between the two groups on the pretest ($p = .52$). As for performance, there were no significant differences between the groups while participants showed systematic performance improvements from the pretest to training Session 1 and from training Session 1 to training Session 2 ($ps < .05$, see Table 1). As participants were novices these learning effects were anticipated.

LA, MA, and HA posttests: manipulation checks

To explore whether the anxiety manipulations were successful during the tests, we performed a Group (control, experimental) × Test (LA, MA, HA) MANOVA on the anxiety scores, heart rates, and effort scores. The analysis revealed a significant multivariate effect of test, Wilk's Lambda = .10, $F(6, 17) = 25.61$, $p < .001$, $f = 3.00$, no multivariate effect of group, Wilk's Lambda = .84, $F(3, 20) = 1.30$, $p = .30$, $f = .44$, and a significant interaction, Wilk's Lambda = .48, $F(6, 17) = 3.13$, $p = .030$, $f = 1.06$. The follow-up univariate analyses revealed an effect of test for all three dependent variables, $F(2, 44) = 21.51$, $p < .001$, $f = .98$, $F(2, 44) = 37.41$, $p < .001$, $f = 1.30$, and $F(2, 44) = 12.78$, $p < .001$, $f = .77$, for anxiety scores, heart rate, and effort scores, respectively. The difference in mean anxiety scores between the groups did not reach the .05 significance level, $F(1, 22) = 3.55$, $p = .073$, $f = .40$ (all other $Fs < 1.00$, $ps > .40$; see also Table 1). Pair-wise comparisons with Bonferroni correction performed for the factor test revealed systematic and significant increases in anxiety, heart rate, and perceived effort from LA to MA to HA, confirming that our anxiety manipulations had been successful (all $ps < .05$). The marginally significant group difference in anxiety scores may suggest that on average the control group reported higher anxiety levels than the experimental group.

LA, MA, and HA posttests: dart scores

The 2 (group: control, experimental) × 3 (test: LA, MA, HA) ANOVA on the dart scores with repeated measures on the last factor yielded a main effect of test, $F(2, 44) = 3.54$, $p = .037$, $f = .40$, which was superseded by a significant interaction between group and test, $F(2, 44) = 3.22$, $p = .050$, $f = .39$. There was no significant main effect of group, $F(1, 22) < 1$, $p = .72$. Posthoc pair-wise comparisons using Bonferroni correction made clear that performance of the experimental group was maintained under both mild and high anxiety conditions compared to the low-anxiety test, $ps > .90$ (see Table 1). Although the control group also managed to maintain performance under mild anxiety, their performance deteriorated under high anxiety (i.e., high on the climbing wall) compared to their low- and mild-anxiety performances, $p = .03$ (marginally significant) and $p = .003$, respectively (see Table 1).

Discussion

The aim of the present study was to investigate whether practicing under mild levels of anxiety prevents choking under higher levels of anxiety on a perceptual-motor task. During the first training session anxiety scores of the experimental group were clearly higher than during the pretest, which was not the case for the control group. Anxiety of the experimental group was no longer higher during the second training session. Note that positive effects of training with anxiety after only one training session were also found by Oudejans and Pijpers (2009). Moreover, anxiety levels still systematically increased from the low anxiety, to the mild anxiety to the high anxiety posttest, which was also supported by the systematic elevations in heart rate. With increasing levels of anxiety during the posttests processing efficiency appeared to decrease, as was shown

Table 1
Mean anxiety scores, heart rates, effort scores, and dart scores ± standard deviations of the control group (CG) and experimental group (EG) during the pretest, training sessions 1 and 2, and the low anxiety (LA), mild anxiety (MA), and high anxiety (HA) posttests.

	Pretest	Session1	Session2	LA	MA	HA
Anxiety CG	1.8 ± 1.63	1.5 ± 1.46	1.3 ± 1.09	1.3 ± 1.34	3.7 ± 2.22	5.7 ± 3.07
Anxiety EG	1.3 ± 1.45	2.6 ± 2.20	1.4 ± 1.22	1.3 ± 1.41	2.2 ± 1.71	3.9 ± 2.35
Heart rate CG	106.7 ± 14.54			109.8 ± 15.75	116.7 ± 16.80	124.3 ± 19.37
Heart rate EG	110.8 ± 15.73			107.2 ± 13.40	112.2 ± 14.51	116.8 ± 13.54
Effort score CG	3.2 ± 2.22	5.2 ± 1.91	3.7 ± 2.19	2.6 ± 2.45	3.5 ± 2.22	4.5 ± 2.34
Effort score EG	3.1 ± 2.06	5.3 ± 2.15	3.6 ± 1.78	2.7 ± 1.61	3.1 ± 1.78	4.4 ± 2.16
Dart score CG	162 ± 13.0	176 ± 10.0	180 ± 9.8	185 ± 14.3	187 ± 7.9	177 ± 14.4
Dart score EG	170 ± 19.8	181 ± 12.8	187 ± 13.8	184 ± 9.3	185 ± 11.7	185 ± 10.6

by the increases in perceived effort over the tests (cf. Eysenck et al., 2007). Despite increasing levels of anxiety, and perhaps due to more invested effort, dart performance of the experimental group remained unharmed over the posttests. Performance of the control group, who had not practiced with anxiety, could also be maintained with increased effort under mild anxiety but this was no longer the case during the high anxiety posttest. Collectively these results seem to suggest that practicing under mild anxiety did help in maintaining performance under higher anxiety.

During the posttests average anxiety levels of the experimental group were not as high as those of the control group, although the group difference did not reach the .05 significance level. Still, an additional effect of training with anxiety may be that anxiety levels decrease. Therefore, it is important to establish that for both groups the levels of anxiety that were reached during the mild anxiety and high anxiety posttests were high enough to evoke decreases in performance. Several studies that also used the anxiety thermometer to measure anxiety consistently demonstrated performance decrements with similar and sometimes even lower levels of anxiety (cf. Nieuwenhuys et al., 2008; Oudejans, 2008; Oudejans & Pijpers, 2009; Pijpers et al., 2003, 2005). Furthermore, the mild and high levels of anxiety that were found can be compared to anxiety levels experienced by students about to enter a written examination (Houtman & Bakker, 1989), novice teachers at the start of their first lecture (Houtman, 1990), or athletes just prior to competition (Bakker et al., 2003). As an example, mean anxiety scores reported by individual and team athletes were 5.5 and 4.2, respectively (Bakker et al.). Similar means (generally ranging between 4 and 5) were found for athletes prior to competition by Krane (1994) using several versions of the MRF scales (comparable to the anxiety thermometer). The relatively high levels of anxiety of both groups in the current study, both during the mild anxiety posttest and even more so during the high anxiety posttest, suggest that the maintenance of performance of the experimental group during the high anxiety test was not the result of low-anxiety levels but rather of acclimatization to anxiety and accompanying processes. Together the results show that practicing with certain levels of anxiety is not just effective in preventing choking under similar levels of anxiety as was found in earlier studies (Beilock & Carr, 2001; Lewis & Linder, 1997; Oudejans; Oudejans & Pijpers) but also under higher levels of anxiety.

As explained in the introduction, following the attentional control theory (Eysenck et al., 2007) it is possible to speculate about why training with anxiety may prevent choking in perceptual-motor tasks. According to this theory, anxiety may not only lead to worry about task performance but also to attempts to reduce or eliminate the negative effects of anxiety on performance by investing additional effort. With this effort an attempt is made to maintain active attention on the task while inhibiting distraction or interference from task-irrelevant information (Eysenck et al.). We propose that these additional self-regulatory processes become more effective during training with anxiety (Oudejans & Nieuwenhuys, 2009). Note that we found increases in perceived effort from the low to mild to high anxiety tests as an indication of more self-regulatory activity. This may explain why performance of both groups was maintained during the mild anxiety posttest as additionally invested effort apparently effectively eliminated negative effects of anxiety. When anxiety further increased additional effort no longer helped in keeping performance of the control group unaffected. For the experimental group additional increases in invested effort did help in maintaining performance.

Thus, even though at this stage we can only speculate about the precise nature of the self-regulatory processes as we did not measure them directly, it seems that the experimental group improved with regard to these additional processes, not just because they showed more effort, but because they showed more effort *and* maintained their performance under high anxiety. Apparently, the experimental group developed more effective strategies to maintain performance, which is in line with the suggestions by Lewis and Linder (1997), the findings of Oudejans and Pijpers (2009), and the conclusion by Mullen and Hardy (2000) that "increases in on-task effort may maintain, or improve, performance, *provided that it is directed towards appropriate processes*" (p. 796, italics added). The results also fit the idea and findings that efforts to cope with pressure are not necessarily effective, that is, coping strategies can be either successful or unsuccessful (e.g., Wang, Marchant, & Morris, 2004). Apparently, increases in invested effort must involve adaptive rather than maladaptive processes in order for performance to be maintained or improved. This may explain why increases in effort observed for the control group did not help in maintaining performance with high anxiety. Exposure to elevated levels of anxiety during practice may be used to develop more effective coping strategies to deal with pressure situations and anxiety. Future studies are needed to gain more insight into the self-regulatory processes involved in training and performing with anxiety, for instance, by focusing on these coping strategies and styles (cf. Wang et al.).

From an ecological psychological perspective, it can also be argued that in training with anxiety, actions of performers become better calibrated to the new constraints and performers better learn to quickly recalibrate their perceptual-motor control when confronted with changing constraints (Oudejans & Nieuwenhuys, 2009; cf. Fajen, Riley, & Turvey, 2009). Whatever the constraints or context in question, specific activities involving these constraints are obviously required to learn about the new relations between performer and environment. Training with anxiety provides an example of such activities that lead to better calibration and more efficient and effective re-calibration processes for performing in situations in which anxiety is increased. Re-calibration may also manifest itself in extra invested effort as it involves attempts to re-optimize detection of task-relevant information while preventing distraction by task-irrelevant information (Oudejans & Nieuwenhuys). To gain more insight into changes in these processes future studies could focus on changes in visual attention while training and performing with anxiety (cf. Behan & Wilson, 2008; Nieuwenhuys et al., 2008).

Finally, it needs no explanation that the current study only provided a first attempt to establish whether training with mild anxiety helps in preventing choking under high anxiety. In this attempt only short-term effects were tested just as in the studies by Oudejans (2008) and Oudejans and Pijpers (2009). Future studies are necessary to examine the enduring effects of training with anxiety over a longer period of time. A next step for future research could also be to investigate experts in their own performance environment, possibly also using qualitative designs (cf. Hanton, Fletcher, & Coughlan, 2005). Replication of the current findings in such circumstances would have far reaching implications for sports and other high-achievement settings, such as police work and fire fighting, as it would imply that appropriate training forms with increased pressure and anxiety may actually help in preventing choking in later performance. In learning to perform well in these settings it is important to gain experience in task execution with the same constraints (physical, technical, tactical as well as psychological) as those encountered in the actual performance environment, be it a decisive event for an athlete or a life-threatening shoot-out for a police officer. It is a challenge for these fields of practice to develop training settings in which relevant constraints are present or at least simulated. The results of the current study show that it is not necessary to actually achieve the same high levels of pressure as encountered during the actual decisive event (such pressures may indeed be difficult to achieve in a training setting). It now appears that practicing with mild levels of pressure, which may be readily simulated in training, already holds promise in preventing choking under higher levels of anxiety.

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